COOK

Operation of the
Derby Dust Collector
in Traction Service

Electrical Engineering

B. S.

1907

UNIVERSITY
OF
ILL. LIBRARY

UNIVERSITY OF ILLINOIS
LIBRARY

Class 1907
Book C77
Volume

Je 07-10M

OPERATION
OF THE DERBY DUST COLLECTOR
IN TRACTION SERVICE

BY

LOUIS PHILLIPS COOK

THESIS

For the Degree of Bachelor of Science in
Electrical Engineering

COLLEGE OF ENGINEERING
UNIVERSITY OF ILLINOIS

PRESENTED, JUNE, 1907

UNIVERSITY OF ILLINOIS

May 28, 1907

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

LOUIS PHILLIPS COOK

ENTITLED OPERATION OF THE DERBY DUST COLLECTOR IN TRACTION SERVICE

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

Morgan Brooks.

HEAD OF DEPARTMENT OF ELECTRICAL ENGINEERING

101867

Digitized by the Internet Archive
in 2013

http://archive.org/details/operationofderby00cook

1907
C77

OPERATION OF THE DERBY DUST COLLECTOR IN TRACTION SERVICE.

If there is any truth in the saying that old age commands respect, compressed air certainly has strong claims for respectful consideration, for its past reaches far beyond the beginnings of recorded history. There can be no doubt that air compressed in some degree found practical application in the very earliest ages of man's history. The reduction of metals from their ores was one of the earliest arts acquired by mankind; and the blast furnace must have been the basis of these processes.

Probably the earliest recorded air-compressor is that found on the walls of a tomb in Egypt, in which two men standing on leather bags of air alternately press them down with their feet to produce a blast for a furnace. The ancients employed compressed air in various ways, as in the "wind-guns of Ctesibus", in forming continuous jets for their fountains, in blasts for forges, and in a great many other ways too numerous to mention. Two hundred years ago, in France, Denis Papin first suggested the use of compressed air for transmitting packages in tubes. In 1829 William Mann took out a patent in England for a compound air-compressor. The description of his patent is a very exact description of the best methods of compressing air today. Only in the last ten years of the 19 th. century were the fundamental principles of economical air-compression put into general practice, though all of them are

UIUC

contained in the patent of William Mann.

The first successful application of compressed air to the transmission of power as we know it, was at the Mont Cenis Tunnel in 1861. The successful work in this tunnel with the percussion drilling machine caused the use of compressed air to speed rapidly, and it was soon found that there were many other purposes for which it could be employed with advantage, especially after economical compression was adopted. Paris has developed an immense system for distributing compressed air for power purposes and now has two great compressor plants and more than fifty miles of distributing pipes, furnishing air at 75 pounds pressure to thousands of customers, who use it for every imaginable purpose. It has also been successfully introduced on tramways, in competition with electric and cable traction systems.

The transmission of air from the compressor to the place where it is to be used is much more simple and effective that is usually supposed. It is found in practice that, allowing a velocity of fifteen to twenty feet per second, there is no noticeable difference in pressure between the compressor and the place where it is to be used several miles away. Common oil well-tubing is largely used for the pipes and if it i is properly put in there is very slight loss from leakage. In good practice there need not be more than one percent loss through leakage, and one percent possibly through friction, in the transmission of air.

High pressure compressors are no longer "freak"

machines, unreliable, and largely experimental. The increasing use of high pressure air has demanded a solution, (once for all) of the problems of high pressure compression; and the pneumatic engineer has been equal to the task. The best thousand pound pressure compressors of today are as reliable, as efficient, as thoroughly "standard", as the lower pressure machines.

There has been some rivalry between compressed air and electricity. A few years ago each viewed the other with suspicion but they are now finding their proper places. Each has a field distinctly its own, into which the other cannot hope to enter with any prospect of success. At points these fields touch or even overlap; but here, instead of rivalry, they join forces, and the result is wonderful from an engineering standpoint. A great masterpiece of this is shown in the electro-pneumatic switch and signal system of the New York Rapid Transit Subway, in which the electric current throws the valve admitting the sturdy power of compressed air from automatic air compressors driven by electric motors. The importance of removing the moisture from compressed air is becoming more generally appreciated under the present tendency towards larger units, and longer and more complex air transmissions. In long pipe lines carrying large volumes of air, moisture, if present, will accumulate in the low places in the line and will ultimately fill the pipe, shutting off the passage until the air pressure forces the water away, often with a destructive "water hammer action".

Now this is a point of vital importance in its bear-

ing upon transmission pipe line efficiency. Going further, to the machine using the air, it is necessary to dwell upon the trouble and delay caused by the freezing of exhaust ports, due directly to the presence of moisture in the air. Occasionally the builders of compressed air machinery meet a situation which forces them to the belief that the real cause of freezing at drills and air motors is not fully appreciated. There is often a mistaken idea that it is the atmospheric temperature which causes this. On the contrary, rock drills have been known to freeze tight at midday in the torrid August sun of New Mexico. The fact is that cold is produced directly by the expansion of the exhaust air. Naturally the trouble is greatest in winter. But if all moisture is removed from the air before expansion, no air motor can freeze up however high the degree of expansion, for the very simple reason that there is nothing to freeze.

But the compressor intercoolers are not wholly adequate for this problem of air drying. At best they can remove only a part of the moisture in the air. There must be some further arrangement for air drying; and this leads to a discussion of "collectors". Aside from removing the water in the transmission pipe line, with increased friction and liability to freeze and aside also from avoiding the trouble with "frozen" air motors, the use of a collector is important in its effect upon the life and operation of the motors. Water is not a good lubricant; equally axiomatic is the fact that oil and water will not mingle. The delivery of water to a drill or

other air motor washes out the libricant, increasing the wear and reducing its effectiveness. Especially true is this in the case of pneumatic tools, where a thin libricant is used. The use of moist air in an expansion engine is practically impossible, a fact largely responsible for the ill-repute of the air motor.

There is a device for drying air that is inexpensive and fairly satisfactory. It is located at a convenient point on the air line. It consists of a sort of receiver about four times the diameter of the main line, and several inches long, arranged in a vertical position. A cock is placed at the lower head for blowing out the moisture as it accumulates. This device brings the air in contact with more pipe surface during its passage. It is a sort of trap for lowering the temperature of the air and precipitating and collecting the moisture. The foregoing apparatus will remove dust from the compressed air as well as moisture. The main difference is that the moisture is in the air when it leaves the compressor while the dust accumulates in it as it passes along to its destination. In a great many cases dust is more detrimental to the uses of compressed air than moisture so the object of a collector would be to collect both the dust and moisture f from the air as it passes through the piping and before it reaches its place of application. The collector should be strong, durable, and as small as possible. It should be placed in the pipe line where it can be easily reached for cleaning as often as may be found necessary.

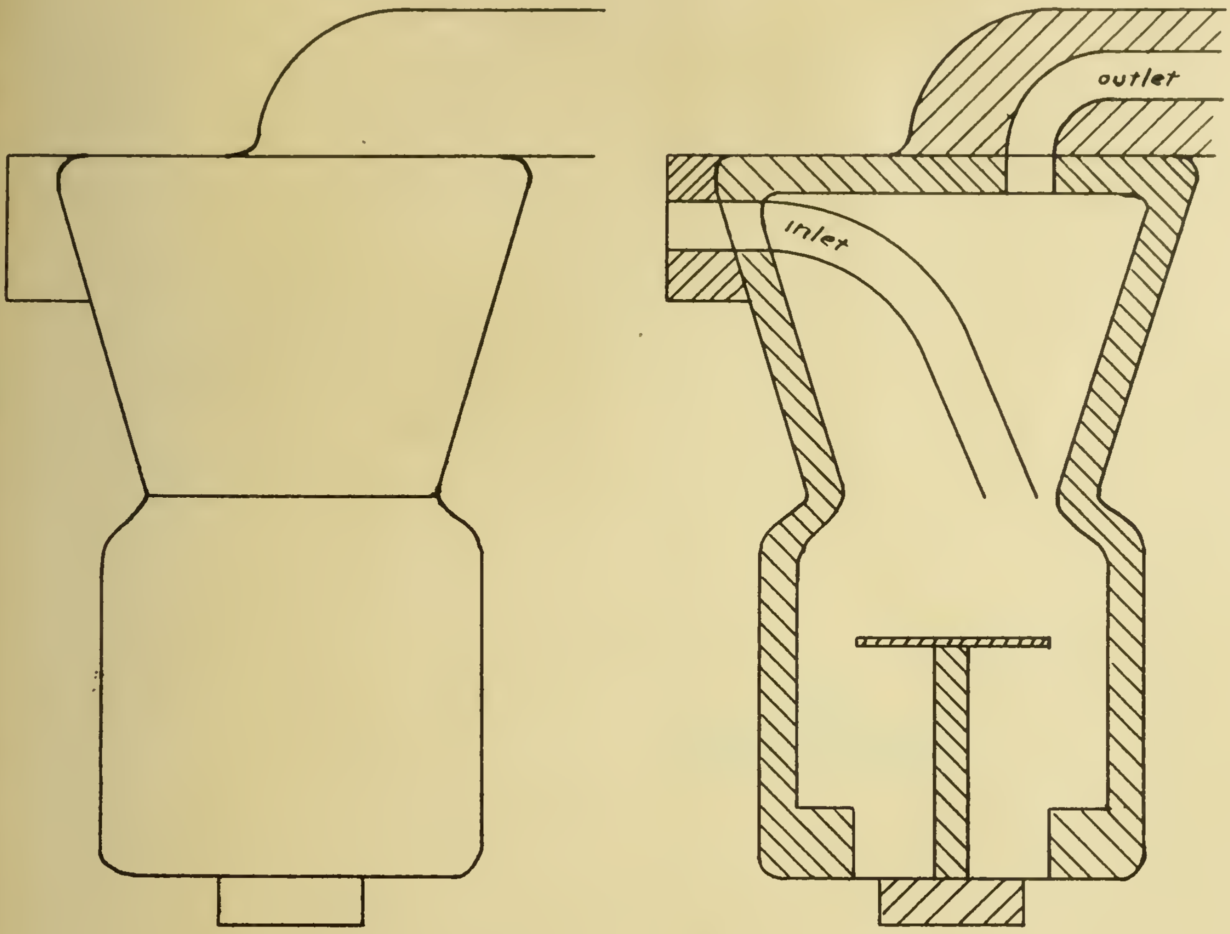
A great many collectors have been tried with only a small degree of success. The one used in these tests seems to have most of the requisites; it is strong and durable, and is both small and light, and could be placed in a pipe line where space is valuable. The principle of this collector is very simple. The air is admitted to the collector as shown in the diagram, and being thrown against the sides very foricbly, the heavy particles of moisture and dust collect on the sides and drain down into the cuplike basin at the base of the collector. This action, of course, presupposes that the moisture in the air is not in the form of vapor, for in that case it being a gas and the air being made up of gases, the law of diffusion of gases would prevent separation, but if the air is chilled before going into the collector, by expansion or otherwise, chilled enough to create a mist, the finely divided particles of water and dust in suspension can then be thrown down and removed by the collector.

The collector used in these tests was the Derby dust and moisture collector. It is made of cast iron and the main part of it is in one piece. The collector tested is nine inches long and has diameter of about 3 1/2 inches on the outside. The inlet and outlet pipes screw into the collector and the cuplike basin in the bottom of the collector unscrews so it can easily be removed. The cock screws into the side of the collector near the bottom so the water will drain off when the moisture is collected in large enough quantities. All parts and attachments being made to screw together makes it compact

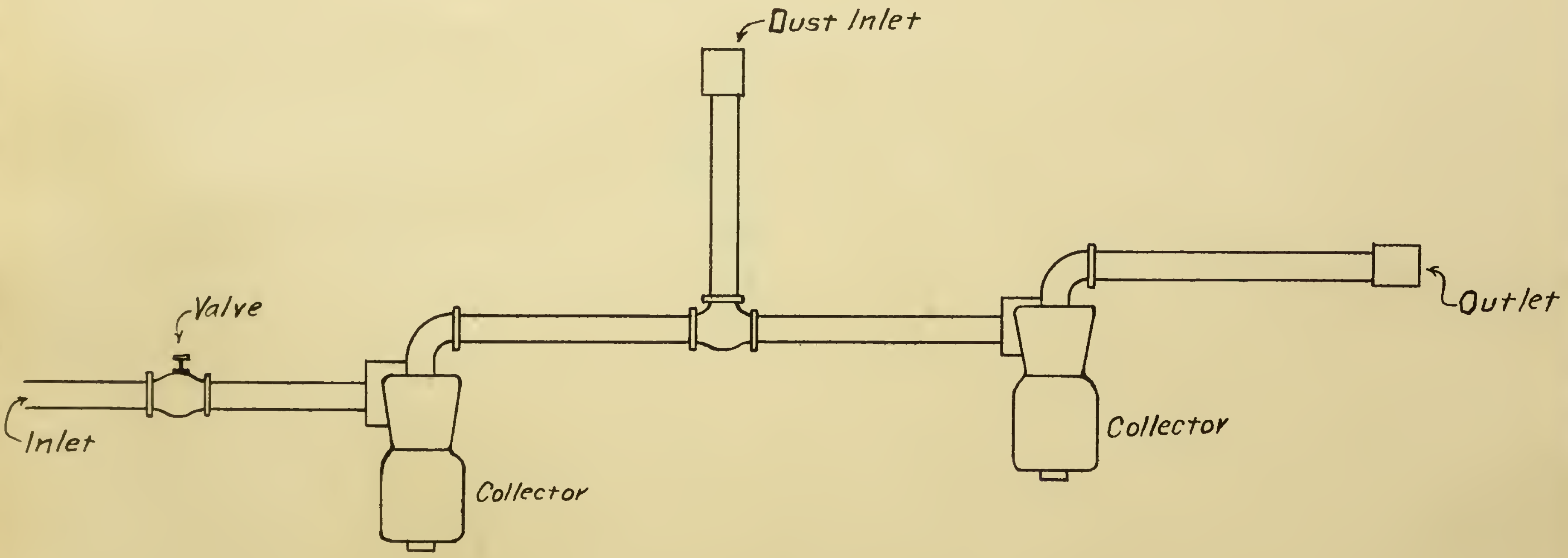
and it can easily be removed or taken down for cleaning. A diagram of the collector on the following page shows how simple it is.

In running tests on this collector to determine how efficient it was in taking dust and moisture out of the air, two collectors were used and two different forms of apparatus set up. In both forms, a collector was placed in the pipe line just ahead of the apparatus to take the dust and moisture out of the air and thus start the air through the apparatus in a pure state. Then with the apparatus which was set up for test, dust or moisture could be introduced into the air in known quantities and in different proportions. Then measuring by some means the amount still remaining in the air after it had passed through a second collector, the efficiency of the collector could easily be determined.

On the following page is a diagram which shows the apparatus as arranged for thedust test. In the piping just ahead of the first collector is a valve by which the supply of air could be regulated. Between the two collectors is a pipe about three feet long and near the middle of this pipe a branch pipe enters. This branch pipe is only a few inches long and was used to introduce dust. The pipe leaving the second collector is about a foot long and during the test a cloth was placed over the end of this so as to catch the dust which remained in the air after passing the collector. To determine at all accurately the amount of dust retained in the second collector was impossible because the dust stuck to the


outlet
inlet

LIBRARY
OF THE
UNIVERSITY OF ILLINOIS.


Dust Inlet
Valve
Outlet
Inlet
Collector
Collector

LIBRARY
OF THE
UNIVERSITY of ILLINOIS.

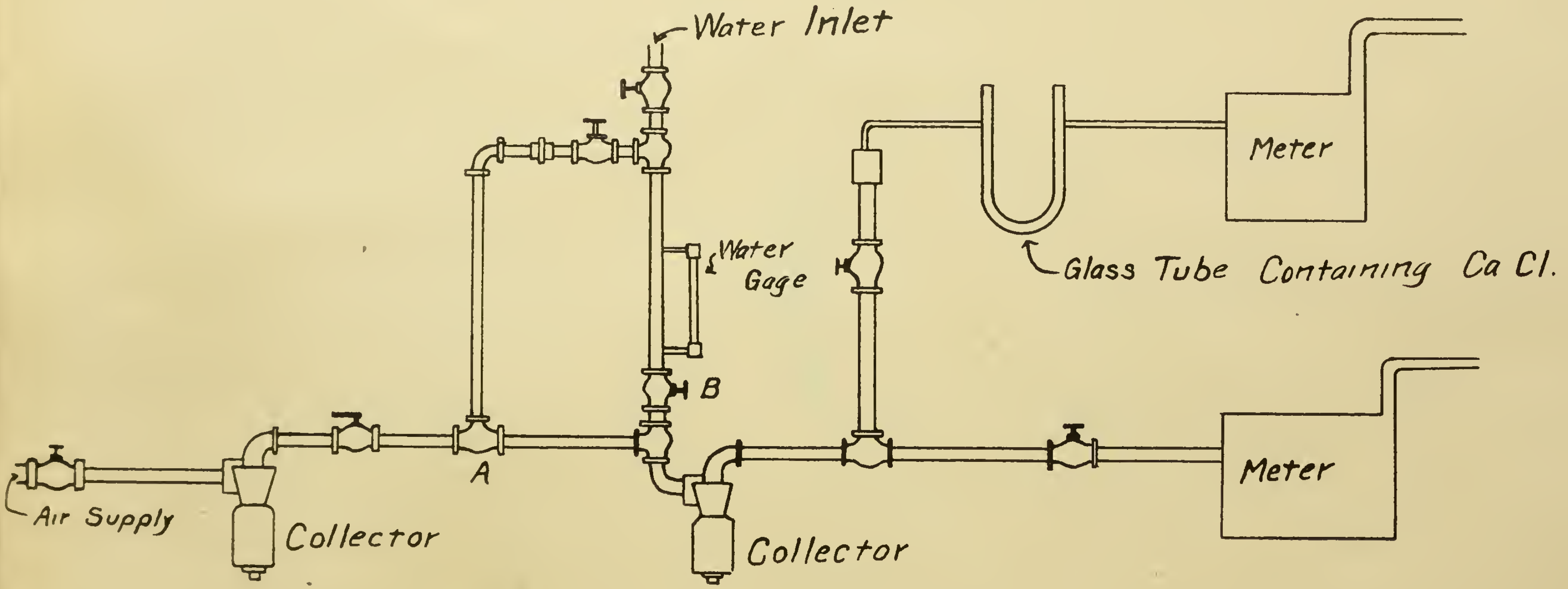
sides of the collector and could not all be removed when the cuplike basin was emptied. However, the efficiency of the collector could be calculated from the amount of dust put in and the amount still in the air after it had passed through the collector.

Fifteen tests were run with five different speeds of air and different amounts of dust were put into the air for the different tests. Dust had to be deposited in the branch pipe before the air was turned on. A small portion of the dust was probably thrown into the collector in a cloud by the first gust of air but the remaining portion would go more slowly and by allowing the air to flow for some time the dust would mix pretty thoroughly with the air while in the collector. In order to determine the amount of dust in the air after passing the collector, the cloth, which was fastened over the end of the pipe, was carefully weighed both before and after the test, the difference between the two weights being the amount of dust not removed from the air by the second collector. On the following page is a data sheet for these tests giving the full details of the tests and the efficiency of the collector for the different speeds of air and the different amounts of dust put into the air. It is seen from the data that the efficiency of the collector in regard to dust runs from 98.2 to 99.2. The amount of dust put in does not seem to make any marked change in the efficiency, but as the speed of the air increases the efficiency seems to decrease.

The testing of the collector for moisture was a more

Approximate Cu.ft. per Min.	Grams of Dust put in Air	Grams of Dust in Air After Passing Collector	% Eff.
5	2.92	.020	99.3
5	1.29	.010	99.2
5	3.44	.020	99.4
10.5	1.41	.015	98.9
10.5	1.42	.015	98.9
10.5	3.06	.030	99.0
20.5	.45	.005	98.9
20.5	.59	.005	99.1
20.5	3.25	.040	98.7
27.5	1.57	.020	98.7
27.5	1.71	.030	98.3
27.5	3.47	.050	98.5
38.5	2.17	.030	98.6
38.5	1.59	.030	98.2
38.5	4.29	.050	98.8

complicated problem in one respect and less complicated in another. The apparatus could be arranged so that water could be mixed with the air in different proportions while the tests were being run. It was, however, more complicated in that it was difficult to determine the quantity of moisture still in the air after passing through the collector. On the following page is a diagram of the apparatus used in these moisture tests. At the left is the first collector and just in front of this is the valve which controls the supply of air to be admitted for the tests. At "A" the pipe branches off; the main line going on to the second collector while the branch line leads into the pipe holding the water, to be mixed with the air before it goes into the second collector. A water gage is placed as shown to indicate by its change of level the rate of flow of water. The valve at "B" controls the supply of water by action of gravity since there is the same pressure both above and below the water column. As this water mixes with the air it goes into the collector. The problem now was to determine the amount of moisture still in the air after passing through the collector. The best way to do this under the existing circumstances was to send the air through a tube containing calcium chloride. Calcium chloride is a good absorbant of moisture and by carefully weighing the tube both before and after the test, the amount of moisture taken up by the calcium chloride would be obtained. This would also be the amount of moisture left in the air after passing through the collector because as long as the calcium chloride is kept


Water Inlet
Meter
Water Gage
Glass Tube Containing Ca Cl.
B
A
Meter
Air Supply
Collector
Collector

LIBRARY
OF THE
UNIVERSITY of ILLINOIS.

fairly well dried it takes all of the moisture out of the air which passes through it. This process would have been fairly easy if the tube containing the calcium chloride had have been large enough to take all of the air but the best tube obtainable was rather small so a branch was placed in the pipe and valves arranged so the supply of air to the tube could be regulated according to its capacity. Each branch of the pipe line then led into a meter so the amount of air passing through the tube and the amount of the remaining portion of the air would be known. From this data the total amount of moisture in the air after passing the collector could be determined.

Several different tests were made upon the collector in regard to the moisture which it would take from the air. Five different speeds of air were used, the same as in the dust tests but each speed was run twice for the same length of time and with the same amount of water put in; one being a check upon the other. Following are data sheets for these tests showing the full details of the tests and the calculations made. In the first test no water was put into the air and each run was for a duration of five minutes. No water was taken from the air by the collector but the increase in the weight of the tube containing the calcium chloride showed that there was moisture in the air after it had passed through the collector. There was no water put in the air and none taken out by the collector so the amount taken out by the calcium chloride was the amount in the air while it was ordinarily.

passing through the pipe. This, as shown by the data sheet, was small and would probably never cause any trouble. In the next test five different speeds of air were used and each run was for five minutes as before but in this test 45.9 grams of water was let into the air during each run of five minutes. The collector showed itself to be of great value in this test by taking out from 92% to 98% of the water put into the air. Its efficiency was greatest for the lower speeds of air and seemed to decrease as the speed of the air increased. In the next test each run was for ten minutes but the rest of the test was the same as before. Following this was two other tests, one with runs of 20' and the other with runs of 30'. It was impossible to make a run of 20' or 30' for the higher speeds of air because the supply of calcium chloride in the tube was so limited that it became saturated before the end of the time on those speeds. Only the three smaller speeds were used in these two tests. In making the longer runs, the same amount of water was let into the air but it was let in that much slower and therefore became better mixed with the air before going into the collector. In the ten minute test the efficiency runs from 95.2% to 77.5% which is quite a little below that of the five minute test. In the twenty minute test the efficiency runs from 94.5% to 75.4% which is a little below that of the ten minute test. In the thirty minute test the efficiency runs from 82.6% to 60.5% which is far below that of the twenty minute test. In all of these tests the efficiency of the collector decreased as the speed of the air increased.

Wt. of U Tube in Grams		Water Put in Air	Water Taken out by Collector	Water in U Tube	Air ①	Air ②	Total Air in Cu. ft.	Time	Water in Air After Passing Collector	Grams Water per Cu. ft. of Air	Cu. ft. of Air per Min.
Before	After										
102.78	103.62	0	0	.84	18.5	4.9	23.4	5'	4.00	.171	4.68
103.32	103.72	0	0	.40	19.7	2.7	22.4	5'	3.32	.148	4.48
103.62	104.00	0	0	.38	49.3	2.3	51.6	5'	8.52	.165	10.32
103.72	104.10	0	0	.38	55.0	2.8	57.8	5'	7.84	.135	11.56
104.00	104.53	0	0	.53	92.4	2.3	94.7	5'	21.82	.230	18.92
104.10	104.90	0	0	.80	99.4	3.8	103.2	5'	21.72	.211	20.64
104.53	105.32	0	0	.79	131.2	4.0	135.2	5'	26.72	.198	27.04
104.90	105.72	0	0	.82	131.8	4.4	136.2	5'	25.38	.186	27.24
105.32	106.27	0	0	.95	190.0	4.8	194.8	5'	38.55	.197	38.96
105.72	106.70	0	0	.98	178.0	5.7	183.7	5'	31.58	.172	36.74

Wt. of U Tube in Grams		Water Put in Air	Water Taken out by Collector	Water in U Tube	Air ①	Air ②	Total Air in Cu. ft.	Time	Water in Air After Passing Collector	Grams Water per Cu. ft. of Air	Cu. ft. of Air per Min.	% Eff.
Before	After											
99.27	99.65	45.7	44.9	.38	24.4	1.2	22.6	5	7.2	.316	4.52	98.0
99.64	99.80	45.7	44.8	.74	20.3	2.3	22.6	5	7.3	.322	4.52	97.8
99.65	100.25	45.7	44.7	.60	50.0	1.7	51.7	5	18.2	.353	10.34	97.5
99.80	100.44	45.9	44.4	.64	51.4	2.2	53.6	5	15.6	.291	10.72	97.0
100.25	100.85	45.9	43.5	.60	100.5	2.0	102.5	5	30.7	.300	20.50	94.7
100.44	101.35	45.9	43.4	.91	98.0	2.7	100.7	5	33.9	.337	20.14	94.7
100.85	101.76	45.9	43.9	.91	132.0	3.2	135.2	5	38.4	.285	27.04	95.7
101.35	102.20	45.9	44.1	.85	134.2	3.0	137.2	5	38.8	.283	27.44	96.1
101.76	102.79	45.9	43.0	1.03	190.6	3.2	193.8	5	62.4	.322	38.76	93.8
102.20	103.25	45.7	42.1	1.05	191.0	3.4	194.4	5	60.1	.309	38.88	92.0

Wt. of U Tube in Grams Before	After	Water Put in Air	Water Taken out by Collector	Water in U Tube	Air ①	Air ②	Total Air in Cu. ft.	Time	Water in Air After Passing Collector	Grams Water per Cu. ft. of Air	Cu. ft. of Air per Min.	% Eff.
106.85	107.49	45.9	43.7	.64	52.5	2.3	54.8	10	15.2	.278	5.48	95.2
107.49	108.32	45.9	43.3	.83	51.5	3.9	55.4	10	11.8	.213	5.54	94.5
108.32	109.16	45.9	39.8	.84	81.5	3.9	85.4	10	18.4	.216	8.54	86.9
109.16	110.02	45.9	42.5	.86	101.7	5.4	107.1	10	17.1	.159	10.71	92.7
101.36	103.81	45.9	42.5	2.45	196.0	8.5	204.5	10	59.0	.288	20.45	92.7
103.81	105.81	45.9	42.0	2.00	216.0	7.8	223.8	10	57.3	.256	22.38	91.6
101.37	103.79	45.9	42.7	2.42	271.7	8.6	280.3	10	58.7	.209	28.03	93.1
105.81	107.70	45.9	36.4	1.89	265.0	9.3	274.3	10	55.7	.203	27.43	79.5
103.79	105.66	45.9	38.2	1.87	378.0	7.2	385.2	10	100.1	.261	38.52	83.3
105.66	107.38	45.9	33.5	1.72	365.5	8.7	374.2	10	74.1	.195	37.42	77.5

Wt. of U Tube in Grams		Water Put in Air	Water Taken out by Collector	Water in U Tube	Air ①	Air ②	Total Air in Cu. ft.	Time	Water in Air After Passing Collector	Grams Water per Cu. ft. of Air	Cu. ft. of Air per Min.	% Eff.
Before	After											
104.61	106.30	45.9	43.3	1.69	98.2	5.1	103.3	20	34.3	.333	5.16	94.5
106.30	108.24	45.9	42.5	1.94	84.5	10.1	94.6	20	18.1	.192	4.73	92.7
100.47	103.58	45.9	37.7	3.11	190.8	11.0	201.8	20	57.0	.286	10.09	82.2
108.24	109.8	45.9	37.8	1.67	205.3	6.7	212.	20	51.8	.254	10.60	82.5
103.58	107.75	45.9	35.8	4.17	404.	19.3	423.3	20	91.4	.217	21.16	78.1
103.40	106.85	45.9	34.6	3.45	390.7	12.4	403.1	20	112.1	.278	20.15	75.4

Wt. of U Tube in Grams Before	Wt. of U Tube in Grams After	Water Put in Air	Water Taken out by Collector	Water in U Tube	Air ①	Air ②	Total Air in Cu. ft.	Time	Water in Air After Passing Collector	Grams Water per Cu. ft. of Air	Cu. ft. of Air per Min.	% Eff.
112.25	114.85	45.9	37.7	2.60	155	9.8	164.8	30	46.4	.282	5.49	82.6
114.85	118.68	45.9	37.7	3.83	159	18.0	177.0	30	37.7	.213	5.90	82.2
108.65	113.88	45.9	37.1	5.23	322.5	20.6	343.1	30	87.3	.254	11.43	80.8
113.88	117.88	45.9	36.1	4.00	321.5	17.4	338.9	30	78.0	.230	11.29	78.8
105.78	112.53	45.9	32.5	6.75	560.7	26.6	587.3	30	149.2	.254	19.58	70.9
104.95	110.25	45.9	27.7	5.30	598.	20.1	618.1	30	162.7	.262	20.60	60.5

The efficiency also decreased as the length of time for a run increased.

In summing up the test run on the collector to find the efficiency in regard to dust and moisture, I would say that it was an excellant collector for dust but only a fair collector for moisture. The dust tests showed that the amount of dust put in made no difference and the lowest efficiency obtained was 98.2% which was for the highest speed of air obtainable. The moisture tests seemed to show that the efficiency dropped very rapidly as the water became better mixed with the air until in the common run of air where there was only a very small amount of moisture the efficiency became zero. Several runs were made with some unslacked lime and calcium chloride in the cuplike basin of the collector to see if they would take the moisture out of the air when there was very little moisture in the air but they failed to do so. The unslacked lime took up none at all while the calcium chloride took up just a little on the top which was all of it that came in contact with the air. Therefore in conclusion I will say that from my observations in these tests, the Derby dust and moisture collector is an excellant collector for dust but is only a fair collector for moisture.

UNIVERSITY OF ILLINOIS-URBANA
3 0112 086825210